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Map-Based Cloning of SUN, a Gene That Controls Variation in Tomato Fruit Shape

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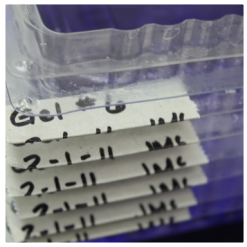
Background

Consumers have high expectations when it comes to the appearance of fresh foods. An Ohio State University study showed that appearance, including color and shape of fruit, ranks very high in consumers' purchasing decisions. Currently there are varying tomato fruit characteristics—from small to large sizes and from round to elongated and pear shapes—yet the growth and development of fruit on a molecular level is, at present, not very well understood. The United States is currently the leading exporter of fresh market tomatoes, and Ohio ranks fourth among the nation's leading tomato producing states. Researching the genetics of a tomato crop has potential positive economic impacts for such a valuable state and a national export. Understanding what the consumer wants from the produce and how to create that product genetically can positively affect the industry.

Objectives

The goal of this SEEDS project was to determine how, on a molecular level, fruit changed from a round shape (as seen in the wild relatives of many tomatoes) to an elongated shape (as seen in modern processed tomatoes).

Tomatoes were chosen for this research because they belong to a very important horticultural crop group that includes potatoes, peppers, and eggplants and because of the extensive information available on tomato genomics. They are one of the most diverse vegetable crops in terms of shape and size variations. Previous genetic analysis identified a region, or loci, of the tomato genome that harbors the gene responsible for variation in fruit shape. The locus or gene, dubbed SUN, regulates the tomato's shape from round to elongated.



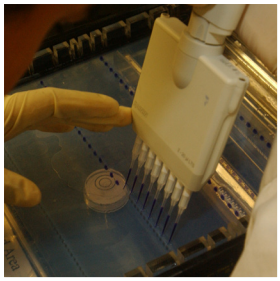
Results

The major objective of this study was to narrow the region of the tomato gene that harbors SUN. Molecular markers were also developed to aid mapping studies. Additional genome structure analyses showed that this SUN region of the genome is highly dynamic and that it recently underwent an insertion event, which may be the direct cause of the change in fruit shape. The results showed that the SUN-harboring gene is located within a 68 kb interval on tomato chromosome 7. Furthermore, approximately 100 kb from SUN, an inversion of a part of chromosome 7, occurred in one of the tomato's wild relatives.

Once SUN was identified, the next step involved proving whether this gene was actually responsible for causing changes in fruit shape. To do so, investigators conducted several plant-transformation experiments. When the SUN gene was introduced into wild, round, fruit-bearing tomato plants, the result was extremely elongated fruit. When the gene was "removed" from elongated fruit-bearing plants, the plants produced round fruit comparable to the wild tomatoes.

Impacts

Dr. van der Knaap's current objective is to continue map-based cloning of SUN, utilizing other types of genomic libraries. The locus SUN has now been elucidated in several other heirloom tomato varieties that display elongated fruit shape. This result suggests that the locus may be key to the domesticated tomato's change from round- to oval-shaped fruit. Once all the genes are selected during the domestication process, scientists will be able to piece together how domestication shaped the tomato fruit and they will gain a better understanding of what controls the shape of other very diverse crops such as cucumbers, peppers, and squash. The work could also open the door to "designer" tomatoes and other vegetables by breeding new varieties to serve specialty markets and by allowing processors to cut costs.



This work greatly contributed to the development of molecular markers that aid tomato genetic analysis and breeding projects. The data were used to write several successful grants to the National Science Foundation, the first receiving $1.1 million. This research also appeared on the cover of the prestigious journal, *Science*.

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